INTRODUCTION: BUILDING CANADIAN SCIENCE

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Why was the National Research Council of Canada conceived? In one sense, it was meant to be similar to its prototype in Britain, which evolved into the Department for Scientific and Industrial Research (DSIR) and its sibling in Australia, the Council for Scientific and Industrial Research (CSIR),[1] all founded during World War I, ostensibly to aid the war effort. Yet, it was perceived by many as a means to improve Canada's capability in industrial research and development. Throughout most of its seventy-five years , the NRC was seen in the latter light, as well as in many others. The ambivalence of the Canadian government and industry toward the work of the Council's scientific laboratories is perhaps even more profound now than at any time in its history.

During three quarters of a century, the National Research Council has tried to play many roles. There was ambiguity at its birth, when it was created by order-in-council in 1916. On the one hand, the Imperial cabinet urged that the Dominions organize scientific research for the war effort. On the other hand, Canadian scientists and industrialists had argued, for some years, that a national institution was necessary to assist nascent Canadian technologies.

Could such a council offer advice to cabinet on science policy? It was already obvious by 1916 that the country's elite scientific organization, the Royal Society of Canada, founded by Governor-General Lord Lorne in 1882, could not fulfil that function. When advice was required, it could be had within departments. During the Laurier years, powerful ministers like Clifford Sifton managed to make decisions without reference to an external body.The foundation of the Dominion Observatory is an excellent example of this personal approach,[2] as was the creation of the Canadian Conservation Commission which competed with the NRC in a federal bureaucracy power struggle (see Girard's article, below).

The coordination of a scientific war effort was wishful thinking in 1916: Canada's science and technology, at least as might be applied to defeating the Central Powers, was too rudimentary to be organized in any meaningful way. At any event, when the Armistice was signed in November 1918, there was no Canadian

1 The Australian council had much in common with the Canadian; see C.B. Schedvin, **Shaping Science and Industry** (Sydney, 1987).

2 See R.A. Jarrell, 'The Origins of the Dominion Observatory, Ottawa,' **Journal for the History of Astronomy** 22 (1991), 45-53.

scientific war effort in place, only a few Canadian scientists involved in an individual way and hired directly by British institutions like the Board of Invention and Research. The next seven decades saw a long series of attempts by the Council to define itself within the Canadian context.

In the following pages, we will highlight some of the themes in the history of the NRC, with the understanding of the reader that such a sketch cannot be comprehensive and only signposts can be mentioned. The early history has its chronicler.[3] A larger-scale history appeared at the half-century mark of the Council's history.[4] The past quarter-century, possibly the most critical of all, awaits its historian. Because so few historians of science have yet to focus upon Canadian institutions, the articles in the following pages can only touch upon selected problems in the NRC's history. The reader is directed to Donald Phillipson's article on NRC historiography, as well as the chronology and bibliography, concluding this volume for further information on other facets of the Council's rich history. We will concentrate upon the last quarter-century of NRC activities.

The history of the NRC can be divided conveniently into five phases (*pace* Phillipson, below), bearing in mind that such a schema is meant to be convenient and not explanatory. The first period, from 1916 to 1929, when its laboratories were authorized, represents the formative years in which the NRC struggled to define itself as an institution and to define its role with respect to possible competitors. The second encompasses the period before the outbreak of World War II; the energies of the NRC went towards the creation of its own laboratories and the search for useful work for its staff. The third period, the war years (1939-45) saw rapid growth, an almost complete focus upon military research and secrecy. The post-war era appears to have two phases: from 1945 to the 1966 NRC Act, a much larger and far more diverse NRC, with a strong commitment to pure research, reached its zenith. This was its period of greatest impact upon Canadian science and technology, as well as international renown. The recent decades, however, have been marked by uncertainty, if not a loss of direction. We will examine these periods briefly.

Today, when we speak of the National Research Council of Canada, we tend to think of its laboratories, but NRC officials always reminded us of the distinction between the Council, an appointed body of academics, industrialists and others and the laboratories themselves. The Honorary Advisory Council was estab-

3 Mel Thistle, **The Inner Ring: The Early History of the National Research Council of Canada** (Toronto, 1966).

4 Wilfrid Eggleston, **National Research in Canada: The NRC 1916-1966** (Toronto, 1978).

lished to advise the Privy Council Committee on Scientific and Industrial Research, a cabinet committee of those ministers most directly involved in science and technology. The link between the two was the minister for Trade and Commerce. So, as the war ended, the new council was to coordinate and to advise. Coordinate what? Advise about what?[5] This was the conundrum for the early council, chaired by University of Toronto physiologist A.B. Macallum.

The appointment of a council was not merely a colonial response to an Imperial request, as the question of technical education and the lack of industrial research in Canada had been debated for some years and action urged by groups such as the Canadian Manufacturers' Association. The most concrete attempt to attack the problem was made by the Royal Canadian Institute.[6] There was no significant military research to coordinate during the war, but could scientific and industrial research be coordinated? The survey of Canadian research capabilities, made by the Council in 1917, seemed to reveal a very meagre cadre of industrial researchers, although recent scholarship suggests the survey underestimated the real potential.[7] Clearly, the coordination of federal government science was out of the question – the notion of a science ministry was not seriously mooted until the 1960s – because of the rivalry of government departments with scientific branches, such as the Department of the Interior (and its successors) and the Department of Agriculture. The documents assembled by Thistle speak eloquently of the atmosphere of suspicion that greeted the early work of the Council.

The Council insisted that it remain at some distance from government by reporting directly to a minister, thus circumventing departmental control, and successfully resisting the Civil Service Commission once it had its own employees, which did little to endear it to the bureaucracy. These were not easy years for what became known officially in 1925 as the National Research Council. What emerged as the primary desire of the Council was the creation of a National Research In-

5 The 1916 terms of reference for the Council adjure it to investigate scientific and industrial research in universities, government departments and in the private sphere and 'to coordinate these agencies so as to prevent overlapping of effort, to induce co-operation and team work, and to bring up a community of interest, knowledge, and mutual helpfulness...' **First Annual Report, 1918,** 7. In this period, such an injunction was more hopeful than helpful.

6 See Philip C. Enros, 'The "Bureau of Industrial Research and School of Specific Industries": The Royal Canadian Institute's Attempt at Organizing Industrial Research in Toronto, 1914-1918,' **HSTC Bulletin** 7:1 (Jan. 1983), 14-26.

7 James P. Hull and Philip C. Enros, 'Demythologizing Canadian Science and Technology: The History of Industrial Research and Development,' in Peter Karl Kresl, ed., **Topics in Canadian Business** (Montréal, 1988).

stitute. The vicissitudes of this project have been well documented (see Enros' article below). There were excellent practical arguments for the creation of such an institution – some of these arguments pre-dated the war – and we should note that early in the century, Canada had established a number of scientific institutions, the kinds of institutions that all self-respecting nations possessed. Parliamentary support for the idea was voiced by two select committees chaired by Hume Cronyn advocating its establishment. Although the bill to establish Council-operated laboratories was defeated in the Senate in 1921, the concept, which had been a matter of faith since the first days, would remain so until the NRC's efforts were crowned by success with the opening of the Sussex Drive building in 1932.[8]

Apart from advising and coordinating, both fraught with political difficulties, what else could the NRC undertake? The two ideas that emerged were simple but remarkably effective: a scholarship and grant programme to assist Canadian universities in the production of research personnel and to support individual research and the associate committee scheme to tackle specific research problems in a cooperative manner. The scholarship programme was an inspired method of intervening in higher education; there was, of course, always the potential of conflict with provincial governments, as education was a jealously-guarded provincial power.[9]

The advantage of both schemes was that neither trod upon the toes of federal government departments. In the case of student scholarships and research grants, the NRC entered virgin territory. Research in the universities was still a relative novelty by 1920.[10] The reproduction of research personnel was not generally supported by universities or provincial governments. These schemes, which survived well into the 1970s before being removed to a different agency, were perhaps the way in which the NRC had its most significant impact upon the growth of Canadian science. At the end of NRC's administration of the programme, nearly $100 million was being expended annually on grants and scholarships.

8 The opening of this splendid building was rendered anticlimactic by government austerity measures; for some years, the NRC could not fill the building.

9 When the Royal Commission on Technical Education was formed before the war, the then Minister of Labour, W.L. Mackenzie King, took great care to reach consensus with provincial governments.

10 Yves Gingras, **Physics and the Rise of Scientific Research in Canada** (Montreal and Kingston, 1991); R.A. Jarrell, **The Cold Light of Dawn: The History of Canadian Astronomy: A History of Canadian Astronomy** (Toronto, 1988).

The associate committee programme, on the other hand, was a relatively economical means of bringing together university (and occasionally industrial) expertise to solve practical problems. The associate committee structure had a great influence upon the growth of scientific disciplines in Canada.[11] They were flexible means to react quickly to new situations. The Associate Committee on Tuberculosis in the inter-war years and the wartime committee for Medical Research, for example, not only served to solve urgent practical problems but also raised the question of an appropriate structure for funding medical research (see Feldberg's and Romano's articles below). Although medical research was not part of the original mandate for the NRC, it could thus be tackled in a practical and evolutionary manner through the medium of the associate committee up to the point when growth justified the creation of a whole Division of Medical Research (see Li's article below). Though the work of the associate committees is less well known than the research performed in the NRC laboratories, opened in 1932, it had lasting effects on the Canadian system of research. The continued existence almost to this day of these committees (they were abolished in 1991) also shows that after having won the battle for the erection of central laboratories in Ottawa, the NRC did not simply abandon the committee system and turn upon itself, but continued to be sensitive to problems raised by outside scientists. In 1929, for example, the president of NRC, H.M. Tory, decided to create the *Canadian Journal of Research* to solve the problem of the diffusion of the growing amount of research results coming out of universities aided by NRC grants and scholarships, a problem brought to his attention by associate committees like the one for physics and engineering physics, and which could not be solved by the Royal Society of Canada.

The inauguration of the NRC laboratories in the Depression was unpropitious. Had they appeared in good economic times, they might have made a greater immediate impact. As it was, the research teams had to stretch to make any contribution, and then often only with government contracts, such as with researches on wheat growing or for the RCAF in aviation technology.[12]

Everything changed with World War II. Industrial research immediately faded into the background and war research move to the fore.[13] One important change

11 For a useful summary of NRC associate committees, consult Donald J.C. Phillipson, **Associate Committees of the NRCC, 1917-1975** (Ottawa: National Research Council of Canada, 1983).

12 W.E.K. Middleton, **Mechanical Engineering at the NRCC, 1929-1951** (Waterloo, 1984), and **Physics at the NRCC, 1929-1952** (Waterloo, 1979) and Norman T. Gridgeman, **Biological Sciences at the NRCC: the Early Years to 1952** (Waterloo, 1979).

13 Wilfrid Eggleston, **Scientists at War** (Toronto, 1950).

was in the style of leadership of the Council; until 1939, the two presidents – who had replaced the earlier administrative chairmen – H.M. Tory and General A.G.L. McNaughton, had operated under a 'command' structure, both being strong, authoritarian leaders, albeit with different styles.. McNaughton's acting replacement as president, C.J. Mackenzie, was an engineer from academe. The great advantage that Mackenzie possessed, given wartime secrecy and urgency, was a personal relationship he developed with a powerful member of cabinet, fellow engineer (and American-born) C.D. Howe.[14] Wartime exigencies meant that the Council no longer had the luxury of discussion but had to act. For the most part, the personal relationship between Mackenzie and Howe during the war worked for the benefit of the NRC (and the country), though this was not always an unalloyed benefit.[15]

The great expansion of the NRC laboratories meant new areas of science opened up to Canadians. Radar research was on obvious area; Canadians had ignored the subject before the war, although a number of countries were involved in research. The arrival of a technological breakthrough – the cavity magnetron – was as important as the Tizard mission that brought it to the New World. The radar programme at the NRC absorbed a great deal of scientific and technical talent and led to a number of important devices,[16] some of which were of value in peacetime, but there were certainly missteps and mistakes, particularly in the move from research to development to production.[17] Whilst admitting that NRC research for the war effort was substantial and often very effective,[18] more detailed research and closer analysis may well show that the results of six years' centralization of science in Canada had drawbacks.

However, one advantage of such centralization was the concentration of young scientific talent; many graduate students and more mature scientists in universities and in government departments dropped their pre-war work and joined Council research teams to work on such tasks as sonar, code breaking, nutrition

14 See Mel W. Thistle, (ed.), **The Mackenzie-McNaughton Wartime Letters** (Toronto, 1975).

15 For the positive view, consult E. Christine King, **E.W.R. Steacie and Science in Canada** (Toronto, 1989), but for balance, see David Zimmerman, **The Great Naval Battle of Ottawa** (Toronto, 1989).

16 W.E.K. Middleton, **Radar Development in Canada: the Radio Branch of the NRCC** (Waterloo, 1981)

17 David Zimmerman, 'Radar and Research Enterprises Limited,' **Ontario History** 80:2 (1988), 121-42.

18 Wilfrid Eggleston, **Scientists at War** (Toronto, 1950).

studies, mass production of explosives and aircraft icing. When the war ended, with the NRC complement an order of magnitude larger than in had been in 1939, a significant number of these younger scientists remained with the NRC and did not return the universities, despite the burgeoning enrolments as the veterans demobilized. The rapid growth of the NRC also served women scientists. Though some had benefitted from scholarships to train as researchers, few were actually employed in its laboratories. It was only with Canada's entry into the Second World War that the door opened for increased employment of women in all areas of research (see Ainley and Millar's article below).

By 1945, a significant nuclear research programme was in place; centred on Montreal during the war, it possessed a first-class facility at Chalk River. Although Canadians were the second nation to build successfully a nuclear reactor (the ZEEP in 1945), we must remember that the heart of the research team was not Canadian, and the leadership for some years was provided by British scientists (Sir John Cockcroft and W.B.Lewis).[19] Nonetheless, the nuclear programme offered a tremendous advantage to young Canadians, who eventually became the key personnel in the field and, like B.M. Sargent at Queen's University, formed other centres for nuclear research in Canada. Given Canadian expertise in 1939, it was most unlikely that such a relatively insignificant country should become an important player in the most exciting post-war scientific field. But, just as Canada's contribution to the war on combat and diplomatic sides propelled it into the league of a major players in NATO after the war, the scientific research programmes of the NRC ensured that Canadian science came much closer to approximating that of its southern neighbour and ally by participating in 'Big Science,' even if on a smaller scale.

The National Research Council, which had been honed into a wartime tool, was still at heart a civilian scientific organization. Neither the administration nor much of the rank and file was eager to continue this work. As a result, the military-oriented research was spun off as the Defence Research Board in 1947, whilst the nuclear programme, the largest single programme in the Council laboratories, became an independent Crown corporation, Atomic Energy Canada Ltd. (AECL), in 1952. Such was the importance of this spawn of the NRC that President Mackenzie left the NRC to become the president of AECL, being succeeded by E.W.R. Steacie, a McGill chemist who had joined the Council laboratories in 1939. The NRC that Mackenzie bequeathed to Steacie was a very

19 Wilfrid Eggleston, **Canada's Nuclear Story** (Toronto, 1965) was an early and relatively uncritical account; see, especially, Robert Bothwell, **Nucleus: the History of Atomic Energy of Canada Ltd.** (Toronto, 1988); for Lewis' contribution, consult Ruth Fawcett, 'The Early Ideas on Nuclear Power Reactors of Wilfred Bennett Lewis,' **Scientia Canadensis** 10:2 (1986), 132-8.

different institution from the one he inherited from Gen McNaughton. First, the NRC was very much larger, in terms of scientific, technical and support staff (nearly 2700 employees), in terms of budget and in terms of physical space, with its extensive campus on Montreal Road. Although many researchers left for further education, university posts and positions with private firms, many remained. A significant number, those who had not transferred to the DRB or AECL, were interested in pursuing pure research, not practical industrial problems. The wartime radar programme, later metamorphosed into the Radio and Electrical Engineering Division, could simultaneously support pragmatic work on antennas and the new fields of radio and radar astronomy under D.W.R. McKinley and Arthur Covington (see Covington's article below). Gerhard Herzberg, who came to the University of Saskatchewan in 1935, but who migrated to the Yerkes Observatory, was lured back to the NRC to organize molecular spectroscopy. Pure science may well have thrived under Mackenzie during peacetime, but Steacie, as an academic chemist and close friend of Otto Maas, clearly had an orientation towards fundamental scientific researches. Otherwise, one cannot imagine, for example, the long-time support for work on electronic music instrumentation by Hugh LeCaine.[20]

If there was a 'Golden Age' of the National Research Council, it was the during the period of Steacie's presidency (he died in office in 1962). The Council oversaw a large and diverse set of laboratories, a national programme of research grants for academics and scholarships for graduate students, a growing post-doctoral fellowship scheme (see Tickner's article below), supported a large and complex group of Associate Committees and supported several national committees of international scientific unions. NRC laboratory positions were prized by university graduates, and the breadth of problems tackled by the various divisions, both fundamental and practical, was greater than any other institution in Canada.

It would not be difficult to argue that the post-war NRC had evolved into large university without students. Like the modern Canadian university, the NRC undertook both pure and applied research, but there is no doubt that much of its agenda was internally generated. With its funding programmes, it had an enormous impact upon the research agenda of the country. It is facile to speak of 'goal displacement' (Doern's term),[21] but could the NRC have evolved in any other way? During the 1930s, the new laboratories attracted very few corporate

20 Gayle Young, **The Sackbut Blues: Hugh Le Caine, Pioneer** (Ottawa, 1989).

21 See G. Bruce Doern, **Science and Politics in Canada** (Montreal and Kingston, 1973).

clients.[22] The enormous demands of military research during World War II necessarily put industrial research 'on hold.' But what of the post-war years? We must recall that well into the 1960s, the Canadian economy boomed, not just fuelled by primary resource industries but also by the manufacturing sector. Engineering and applied science programmes in Canadian universities grew substantially during this period, and nearly all provinces had research councils of their own.[23] And can we dismiss the fact – for it is a fact – that the larger Canadian industries had been dominated by foreign companies since the 1880s? Canadian industry, whether Canadian or foreign owned, was relatively effective in both technology transfer and innovation during this period.[24] There was simply no long queue of sizeable Canadian industries at NRC's doors asking for advice and assistance.

In 1960, before the science policy movement began to make an impression, Steacie could argue that although Canadians had relied heavily upon British and American science earlier, now

> To maintain its position as an advanced industrial country, Canada must allocate to scientific research and development a proportion of our resources comparable to that allocated by other advanced countries.[25]

The implication was that the NRC could play an important role in this agenda.

The National Research Council may have been perceived by many as having downgraded the priority of industrial research during the post-war years, but was never idle in the field. The Technical Information Service grew apace, the National Science Library, founded in 1957, made material available to academics and industry. Technical information was certainly an important function of its successor, the Canada Institute for Scientific and Technical Information (CISTI).[26] CISTI, housed in its new home on the Montreal Road campus by

22 See Middleton, **Physics at the NRCC**, and Gridgeman, **Biological Sciences at the NRCC.**

23 Frances Anderson, Olga Berseneff and Paul Dufour, 'Le développement des conseils de recherche provinciaux: quelques problématiques historiographiques,' **HSTC Bulletin** 7 (Jan. 1983), 27-44.

24 J.J. Brown, **Ideas in Exile** (Toronto, 1967), argues otherwise, but for a much closer analysis of the issue, see Chris De Bresson, 'Have Canadians Failed to Innovate? The Brown Thesis Revisited,' **HSTC Bulletin** 6 (1982), 10-23 and De Bresson and Brent Murray, **Innovation in Canada** (New Westminster, 1984), 2 vols.

25 NRC, **Annual Report, 1960/1961**, 16.

26 CISTI arose, in part, because of a report of the Science Council of Canada, **Report No. 6: A Policy for Scientific and Technological Information Dissemination** (Ottawa, 1969).

1974, had already put into place a variety of on-line computer bibliographic systems for remote users. The NRC's non-technical publication (*NRC Research News*, later *Science Dimension*) featured many articles on research for industry. Still, one of the Council's primary conduits of information, its research journals, remained oriented towards science. Beginning in 1929 as the *Canadian Journal of Research*, the NRC's house scientific journal had, by the mid-1970s, diversified into thirteen journals for biochemistry, botany, chemistry, chemical engineering, earth sciences, geotechnical research, forestry, microbiology, physics, zoology and physiology and pharmacology. A decade later, they were joined by two more for genetics and cytology and for computational intelligence.

The clouds began to gather in the mid-1960s. As Doern argues, the NRC had been treated by Parliament with either respect or benign neglect for decades, but with the report of the Royal Commission on Government Organization (the Glassco Commission) in 1963, trenchant criticism of the NRC's goals and practices emerged and life for the Council has never been the same. Once the Canadian government 'discovered' science policy, centralization seemed to be inevitable, and the centralization of science would *not* be in the NRC. One consequence of the Glassco recommendations, via a report by Dean Mackenzie, was the formation of the Science Secretariat, within the Privy Council Office, in 1964. The cabinet, whose committee on scientific and industrial research had been castigated by Glassco for having met rarely with little effect, now had an in-house source of scientific advice – although on a very small scale – but for the NRC, which by statute had an advisory role (even if rarely exercised), there was now a competitor. The cancellation of the Intense Neutron Generator (ING) project and Queen Elizabeth II telescope on the advice of the Science Secretariat demonstrated that the new organization was no idle threat. Another player appeared in 1966, an arm's-length national advisory board, the Science Council of Canada (abolished in 1992). In 1966, the new NRC Act effectively abolished the Council's advisory role in government science.

The increasing bureaucratization during the Pearson government became more systematic early in the Trudeau regime. The Senate Special Committee on Science Policy, masterminded by Senator Maurice Lamontagne, and the adoption of the Planning, Programming and Budgeting (PPB) methodology by government departments at the beginning of the 1970s, were even greater threats to the traditional way of organizing scientific activity. The Lamontagne report, which reviewed the various models of research and development (R & D), clearly leaned towards more centralized government control,[27] whilst falling short of

27 See the 4 volumes of **A Science Policy for Canada, Report of the Senate Special Committee**

French or Soviet centralization, was certainly much more controlled than the laxer American model. Since the Glassco and Lamontagne reports, government circles believed that the NRC had fallen victim of 'goal displacement,' that it no longer concentrated upon industrial research. The government reforms of the early 1970s would, presumably, force the NRC back on track.

This was the bind that the Council was in. If it were a university in disguise, how could it justify its existence? And how could it proffer industrial advice if few desired it? The conundrum was 'solved' by successive governments by stripping the NRC of its functions and by pressing it to 'return' to its original mission of assisting industrial science. One method of persuasion was to re-orient the Council through its appointments. In 1960, the Honorary Advisory Council consisted of President Steacie, three of his vice-presidents (one doubling as chair of the Medical Research Council), the retired president, C.J. Mackenzie, fourteen university members, one member representing labour and one from industry! By 1975, W.G. Schneider presided over a council with four vice-presidents and a secretary from the NRC, eight university members and nine from the private sector. By 1985, the new order was thoroughly evident: Larkin Kerwin's council had seven NRC officers, four university members, one government member and twelve from the private sector.[28]

Steacie did not live to see the increasing pressures for change. His successors, B.G. Ballard and W.G. Schneider, both staff members who had come up through the ranks, were perhaps not prepared for the new environment. Schneider took most of the heat and had to defend his organization before the Senate Special Committee. He recognized that some accommodation would have to be made and on his assumption of office, the administration was re-organized into three broad categories – intramural research, grants and scholarships, industrial research and promotion – along with the appointment of a délégué-général to advise the president on policy and planning. He was aware that forces were abroad that could dismantle his domain:

> In discussions on science policies it is frequently stated that a disproportionate amount of research in Canada is carried out in federal government laboratories, an inference which is quite misleading and totally unfounded.[29]

on Science, Policy (Ottawa, 1970-74). For a critique, consult F. Ronald Hayes, **The Chaining of Prometheus: Evolution of a Power Structure for Canadian Science** (Toronto, 1973).

28 The francophone participation in those three periods was four, five and six members, respectively. The 1985 council had one woman.

29 NRC, **Report of the President, 1968/1969**, 10.

This was, in fact, an argument used by his predecessors. He argued that in a country with a resource-intensive economy, such imbalances are natural and that an analysis of other developed nations would not show a significant difference from the Canadian pattern of state-performed research.[30] Schneider took pains in his annual reports to argue for a greater government expenditure on science and technology.[31]

One consequence of the insertion of the science policy debate into the NRC's management style was a greater effort, in annual reports, to justify the Council's expenditures. At the time the Senate Special Committee's report was appearing, the *President's Report* noted that the allocation of NRC funds was based upon priorities.[32] Funding fell into two major areas:

A. 'To perform and support research for economic, social and cultural benefits to Canadians' (87%)

-22% for industry (industrial technology and grants)

-8% for societal problems (e.g. fire codes, transport)

-50% to acquire new knowledge (laboratories, grants, facilities)

-7% manpower training and career development

B. 'To transfer the results of NRC research and scientific information generally to industry, other government agencies and the public sector to ensure that desirable social and economic benefits are available to Canadians' (13%)

-9% general scientific information (Associate Committees, conferences, information services, etc.)

-4% scientific data and services (standards, codes, etc)

-0.2% Canadian Patents and Development Ltd

When Larkin Kerwin assumed the presidency, the justification process merged with the government's administrative mind-set to result in a five-year plan. The first NRC five-year plan, adopted in 1980, emphasized industrial research and development. Six broad categories would be targeted: industrial R & D, regional development, energy, core research, social impact studies and effectiveness (i.e.

30 For further thoughts on government and science, see W.G. Schneider, 'The Role of Government as Patron and User of Science and Technology,' **Science Forum** 6:1 (Feb. 1973), 12-16.

31 See, especially, NRC, **Report of the President, 1975/1976**, 10-21.

32 NRC, **Report of the President, 1971/1972**, 10-11.

improvements in administration). On the one hand, an inordinate amount of time seemed to be invested in what could be interpreted as wrong-headed 'sovietization,' but the NRC had to demonstrate its commitment to industrial R & D for self-preservation. Despite problems in implementation due to economic recession in the early 1980s, some of the goals were achieved and a second five-year plan followed for the second half of the decade. Did these plans succeed? One measure was the apparently greater expenditure on industrial R & D related science. In 1985/86, the general expenditure pattern was as follows:

Natural Science & Engineering $ 37,162,000

Social and Economic Problems $ 47,554,000

Industrial Innovation/Development $182,621,000

Standards $ 7,918,000

Administration $ 44,393,000

Employee Benefits $ 19,231,000

Total $408,025,000

Note, however, that the accounting categories themselves had changed. In 1971, a certain amount of industry-related R & D would be included under 'new knowledge.' Of the 1985-86 total, $261,840,000 was expended on NRC laboratories (including administration). The remainder, 35% of the total, was extramural expenditure: $89,200,000 on external contracts, $30,200,000 for university contracts (mostly TRIUMF) and $26,700,000 to national facilities, other agencies and governments. By 1988/89, the extramural expenditure had risen marginally to 37%. Despite the increased emphasis upon joint ventures with industry and increased extramural expenditure, over $300 million was spent in-house by 1989. For nearly sixty years, the NRC believed that its laboratories played a role that universities could not perform; in reviewing an OECD report on national laboratories, President Kerwin could still argue, in 1989, that:

> NRC is cited in particular for our fundamental or long-term research which universities are not as well equipped to do because of teaching commitments and other circumstances.[33]

Thus, the ideal of the university without classes still exists.

The leadership of the NRC, and the degree to which it was bureaucratized, is also an indication of how much change was imposed by external forces. In

33 NRC, **Annual Report, 1988/1989**, 7.

Steacie's day, the NRC required only three vice-presidents. The total number of employees varied little over the years, from just under 3200 in 1967 to 3275 in 1989. Yet, by 1985, the Council had eight people at the vice-presidential level. The expenditure on administration rose from 8% of the budget in 1972 to 10% in 1988. Yet, one could argue that the NRC of the 1980s was a far more complex operation than it was in Steacie's day. In 1985, the research work was overseen by a senior vice-president, with one associate vice-president superintending the Atlantic Research Laboratory, the Herzberg Institute of Astrophysics and the divisions of Space, Physics and Chemistry, another associate vice-president in charge of engineering divisions (Electrical Engineering, Mechanical Engineering, Energy) and institutes (Industrial Materials Research Institute, Institute of Marine Dynamics and the National Aeronautical Establishment). A second vice-president controlled the Biological Sciences Division, Plant Biotechnology Institute, Biotechnology Research Institute and the Biotechnology Network. A third vice-president handled technology transfer departments such as CISTI. The senior vice-president was also responsible for miscellaneous divisions such as national facilities (TRIUMF, Canada-France-Hawaii Telescope, Canadian Institute for Industrial Technology, etc.)

All through the post-war years, the NRC had developed new scientific fields by way of pure research, in medical science (such as studies of antibodies and cancer), in nuclear studies (with fusion research), in fundamental biology (DNA studies and molecular genetics in general), in chemistry (spectroscopy and vitamins) to cite only a few examples. But for all the external complaints, the Council laboratories carried on a rich variety of pragmatic programmes with vigour. In the life sciences, some projects were essentially agricultural (see Estey's article, below), others dealt with food technology, fungi, lichens, Irish Moss cultivation along with human physiology and psychology. The Division of Building Research looked into permafrost construction, insulation, avalanche protection, building codes and, during the energy 'crisis' of the 1970s, alternative energy sources. Transportation technologies were always essential elements of Council research, ranging over icing of railway switches, breakwater construction and road construction. The National Aeronautical Establishment at Uplands Airport in Ottawa, equipped with Canada's largest windtunnel, performed a wide variety of experiments for building and transport concerns. NRC engineers studied lubricants, power transmission, fuel efficiency, windmills, bird hazards to aircraft, wave dynamics and a number of standards problems. Industries were served by research into fabrics , advanced materials, electronics, chemical engineering, etc.

Even the complaint that NRC had placed too much emphasis upon pure science could not always be laid directly at its door; in the case of astronomy, the government decided to dismantle the Dominion Observatories Branch of the Department of Energy, Mines and Resources in 1970 and transfer all of astronomy to

the Council.[34] From that time, Canada's time service – by then a problem in physics rather than astronomy – became an NRC section, whilst the optical and radio astronomers, who could hardly be expected to contribute to industrial R & D, were brought into one organization (eventually the Herzberg Institute of Astrophysics). On the one hand, the NRC was clearly proud of this research group, with its world-renowned Dominion Astrophysical Observatory and one of the most important radio telescopes at the Algonquin Radio Observatory. Many articles on NRC astronomical work appeared in *Science Dimension*, for astronomy appeals greatly to the public. On the other hand, several millions of dollars expended annually on something so lacking in practicality was potentially an embarrassment. There is no doubt that morale amongst the NRC astronomers ebbed substantially over the years as budgets became tighter and conflicting demands vied for those fewer resources.

During all this period, the National Research Council did not neglect its external clientele and the Associate Committee system needs special mention. The following table shows the extent of the kinds of problem areas tackled by Associate Committees in Schneider's early days as president.

NRC ASSOCIATE COMMITTEES 1970[35]

Aerodynamics
Aeronautical Structures and Materials
Agricultural and Forestry Aviation
Aircraft Systems
Automatic Control
Avionics
Bird Hazards to Aircraft
Computers
Crystallography
Culture Collections & Taxonomy of Microorganisms
Earthquake Engineering
Fats and Oils
Forest Fire Protection
Geodesy and Geophysics
Geotechnical Research
Heat Transfer
Instructional Technology
Meteorites
National Building Code
National Fire Codes
Plasma Physics
Propulsion
Protective Coatings Research
Quaternary Research
Radio Science
Railway Problems
Scientific Criteria for Environmental Quality
Space Research

34 Consult Jarrell, **Cold Light of Dawn**.

35 NRC, **Report of the President, 1970/71**, 40ff.

In all, twenty-eight Associate Committees along with dozens of sub-committees and task forces involved 486 scientists from across Canada. Nearly 40% were government researchers, with just over a quarter coming from the private sector. Given Canada's interest in the geosciences, the Associate Committee for Geodesy and Geophysics was the most complex, with subcommittees for aeronomy, exploration geophysics, geodesy, geodynamics, glaciers, geomagnetism, gravity, hydrology, isotope studies and geochronology, meteorology and atmospheric sciences, seismology and volcanology.

Although the system seemed quite effective, Schneider voiced second thoughts:

> Since Associate Committees were first introduced by NRC, Canada has become a scientifically sophisticated country and there are other agencies of government, as well as scientific and professional societies, that are capable of taking much greater responsibility for some of the roles and activities of Associate Committees. These roles are being examined and assessed with a view to clarifying them and formulating guidelines for the assignment of tasks and responsibilities when Committees are established.[36]

This may well have been a response to the external criticism of the NRC's role in so many facets of Canadian science. Yet, the system was mutually beneficial for NRC and non-NRC scientists alike and, although some committees folded, new ones took their place. By 1985, twenty-five Associate Committees existed, along with fifty subcommittees, with some 1000 members. Other committees enrolled both NRC and outside scientists, especially the national committees of the international scientific unions to which Canada subscribed. These grew from twenty-nine in 1970 to fifty by 1985. NRC had also participated in large-scale international cooperative research programmes such as the International Geophysical Year, the International Hydrological Decade, the International Biological Programme and the Global Atmospheric Research Programme. By 1985, in addition to all the above, eleven advisory committees for various laboratories and projects, three divisional review committees and six council standing committees kept NRC staff occupied.

A quarter-century of science policy and increasing government intervention into Council affairs has certainly taken its toll. Despite continuing large budgets, the NRC's responsibilities were whittled away. The postdoctoral fellowship programme was closed down, the Medical Research Council (MRC) became independent in 1960 and the Council's earliest function, its grants and scholarships programmes (a significant portion of the NRC budget), passed to a separate agency, the Natural Sciences and Engineering Research Council (NSERC) in

36 NRC, **Report of the President, 1970/1971**, 36.

1978.. The Space Science Office, with its budget, was removed in the late 1980s to form an independent Canadian Space Agency, directed by Larkin Kerwin. In 1991, under Kerwin's successor Pierre Perron, the associate committee system came to an end. Recent developments suggest even further trimming of budgets and government control of research agendas.

Will the NRC perform a leadership role in Canadian R & D in future? Whether it does survive will depend upon the adroitness of its management to reorganize it to adapt to the rapidly changing political and economic environment of the early twenty-first century. We can only reflect upon seventy-five years of history – well documented by the articles in this collection – and conclude that the National Research Council of Canada, through its many contributions, has truly helped to build Canadian science.